The Relationship Between Reading Comprehension and Conceptual Mathematics of Third Grade Students at a Selected Elementary School

Patrick N. Kariuki

And

Dustin A. Morris

Milligan College

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Abstract

The purpose of this study was to determine the relationship between reading comprehension scores and conceptual mathematics scores of third grade students at a selected elementary school. The sample consisted of 27 students of which 15 were females and 12 were males. Data were collected using a teacher made conceptual math exam and the scores from the STAR Reading test domains of draw conclusions, identify and understand main ideas, identify details, identify and understand sequence, and understand vocabulary in context. The STAR Reading test correlates highly with the national standardized tests and research based data driven decision-making. The scores were analyzed using the Pearson Product Moment Correlation procedure. The results indicated that reading comprehension had a significant relationship with conceptual math ($r. = .84$; $P = .001$). Additionally, a Multiple Regression Procedure was conducted to determine the impact of each of the five reading domains of the STAR on conceptual math. The results indicated that all five reading skills were strong significant predictors of conceptual math ($R^2 = .77$). This indicates that 77 percent of the variance in conceptual math could be explained by the STAR's reading test scores on the five domains. The results suggest that emphasis should be made in teaching the five reading skills in order to raise conceptual math scores.

Key Words: Conceptual Mathematics, Reading Comprehension, STAR Reading

Introduction

Today, students often graduate high school without the needed skills in reading comprehension and mathematics to be successful on college entrance exams. Many of these students must take remedial reading and mathematics courses when entering college. Some college students drop out of college because they do not have the reading comprehension skills necessary to make good grades at the college level. Also, with colleges and universities requiring a probability and statistics course or college algebra before graduation, students often struggle to meet college graduation requirements, due to their lack of skills in mathematics (Anderson & Kim, 2011; Jacobson, 2006).

Reading comprehension, one of the five key literacy skills, and mathematics have become essential to human communication and learning. Without these needed skills, it becomes much more difficult for students to achieve success in college or in a career. Because of this, educational programs have continued to increase their focus on literacy and mathematics, beginning within the first year of entering the elementary classroom. With this in mind, one of the main goals set forth in the No Child Left Behind Act of 2001 was to increase literacy skills and make sure students are reading on grade level, regardless of ethnicity or socio-economic status. Additionally, schools are also expected to achieve state standards in mathematics, with all students becoming proficient (No Child Left Behind [NCLB], 2002).

Another move to help students achieve the skills necessary to be successful in college has come in the form of a Common Core State Standard. Most states are now in the process of

moving over to the Common Core Standards, which are intended to give a clearer path forward in education. The standards that make up Common Core State Standards are generally believed to be more in depth than most previous state standards. This may be most true for mathematics. The standards in mathematics are now more focused on obtaining conceptual skills, rather than teaching a general methodology. The idea here being that students will be more prepared for college and careers because they will be able to explain how to logically arrive at a conclusion and why they used a certain method to arrive at that conclusion. The vision here is a world where students are not penalized for not using a preferred method. If a student can correctly explain his or her answer, it doesn't matter the method. Common Core is more focused on real world problems, or conceptual mathematics, not simple equations and expressions (Dessoff, 2012; Nisbet, 2012).

Often, these conceptual mathematics problems, or real world problems, come in the form of word problems. After all, math outside of the classroom rarely deals with simple algorithms. Without the ability to read and comprehend word problems, students will have difficulty with answering word problems. It is possible that one of the biggest issues in solving word problems is the language used. The argument is that many word problems do not use the same language that children use in everyday life. Therefore, children are struggling with the language, not necessarily the math (Monroe & Panchyshyn, 2005).

Another problem could be that there is a connection between reading comprehension and mathematics. Previous research has shown that reading comprehension, when paired with math computation skills, can predict applied mathematic performance in fourth and fifth graders (Rutherford-Becker & Vanderwood, 2009). Since there is a relationship between word problems and conceptual mathematics, reading comprehension when paired with math computational skills

and applied mathematics, then it is possible that there will also be a relationship between reading comprehension and conceptual mathematics.

Review of Related Literature

Both reading comprehension and mathematics are well-studied subjects, with a lot of prior research. This is primarily due to their importance in education. In order to provide a basis for this research, prior studies that related to this study were reviewed. This literature review looked at both reading comprehension and conceptual mathematics as individual topics to show possible connections. Also research similar to this study that looked at correlations between reading and math is contained in this literature review. Finally, the importance of thinking strategies and their impact on reading comprehension was noted in this literature review. This review is broken down into four sections; literacy and reading comprehension, reading comprehension outside of language arts, mathematics and conceptual math, and reading and mathematics. These are the areas that deal most directly with the variables and nature of this study.

Literacy and Reading Comprehension

Literacy is key to educational success at every level. In fact, the No Child Left Behind Act of 2001 made literacy proficiency a major priority for all primary and secondary schools in the United States (NCLB, 2002). Similarly, Canadian statistics have found that there is a strong link between literacy success in elementary education, and later success in life. These findings led to a research project on how to better educate children by teaching them critical literacy skills beginning in early elementary education. This was a longitudinal action research study that

spanned three years in an urban elementary school serving kindergarten through fifth-grade students. The research team focused on needed components to create a critical literacy program. One of the most important components was the use of effective thinking strategies, which primarily focus on the key literacy skill of reading comprehension (Cooper & White, 2012).

Reading comprehension is the ability to recognize words and understand their meaning in context. Reading comprehension is a metacognitive process. Tbat is to say, students must be aware of their thoughts when they read in order to comprehend and learn the material. Reading comprehension is closely related to another literacy component called fluency. Fluency primarily deals with the ability to recognize a word when reading. Simply put, students will have difficulty comprehending the material if they cannot recognize the word quickly and understand its meaning. As a matter of fact, researchers gave Australian third and fourth-grade students a battery of tests to measure word identification, metacognition, memory, and interest to see what variables would impact reading comprehension the most. The research team concluded that word recognition was the greatest predictor of reading comprehension. The research team also concluded tbat metacognition and interest in the text are also very good predictors of reading comprehension (Beinicke, Schagmuller, Schneider, & van Kraayenoord, 2012). This fits with research that found thinking strategies help build reading comprehension skills, since thinking strategies work on these domains.

Thinking Strategies and Reading Comprehension.

Thinking strategies that help with reading comprehension, noted in the previously mentioned longitudinal action research study at an urban elementary school by Cooper and

White (2012), are active process both before and after reading a text. Before starting a new text, one strategy has students look at what subject the text is going to cover. The students are then asked what they already know about the subject and what they want to know about the subject. After the students read the text, they discuss what they have learned. This strategy is known as the; know, want to know, and learned (KWL) strategy. The KWL strategy works on building metacognitive skills in that it signals students' prior knowledge, and gets the students actively engaged in the material by having them think of what they want to learn, which increases interest in the text. Additionally, signaling prior knowledge helps students recall words and ideas associated with the text. When done in group instruction, students may learn key concepts from other students before they read the text. Both recalling prior knowledge, and using other students' prior knowledge can help students with word recognition. Again, word recognition, metacognitive skills, and interest are all successful predictors of reading comprehension (Beinicke, et. al., 2012).

Cooper and White (2012) were not the only researchers to link the KWL strategy to success in reading comprehension. Douglas (2009) found that the KWL strategy is an effective strategy on emerging readers when using the strategy in an elementary small group setting. Additionally, the research looked at a similar strategy called the Directed Reading-Thinking Activity (DRTA). DRTA also builds on what the student wants to know about a subject. The main idea behind DRTA is for teachers to engage students to begin thinking about what they expect to find in a text. DRTA is directed by the teacher and helps the students to gain interest and ideas that will help them to understand what they are reading. Douglas found that both KWL and DRTA are very successful in improving reading comprehension in emerging readers in early elementary education by building on prior knowledge and interests of the students.

Another set of strategies Cooper and White (2012) found to lead to success in reading comprehension with elementary students is text-to-text, text-to-self, and text-to-world connections. In these strategies, the reader is looking to make personal connections with the text. Text-to-text is used to make a connection with the text the person is reading and a previously read text. Text-to-self is used to make a personal connection between the text the person is reading and their life. Text-to-world is used to make a personal connection between the text that the person is reading and something that they have seen in the real world around them (Simon, 2012). Again, these strategies are called thinking strategies because they get the metacognitive processes stimulated. The students are interested because of their personal connection, and they are more likely to understand the text because by making a real world connection. Looking at the information in all of the noted research studies conducted, there is strong evidence that suggests that metacognition, interest, and word recognition have a relationship with reading comprehension. While this is important in language arts classes, it also extends to any subject where reading comprehension skills are needed.

Reading Comprehension Outside of Language Arts

When discussing reading comprehension, it is key to understand that its importance exists beyond language arts classes such as English, reading, and writing. For instance, one study looked at the KWL strategy being used for four semesters in a physics course. The study found that the KWL strategy was successful in achieving results better than those of the traditional teaching methods in physics ("Actively Engaging Students in Learning Physics Using the KWL Method," 2001). The reason that reading comprehension models are successful in fields like physics is that students must comprehend the material. Material in most classes will often be

presented audibly, visually, and with hands on materials. However, textbooks journals, and other expository texts will be used as well.

Of course, reading comprehension and other critical literacy skills are important to subjects like social studies as well, since much of the information is presented in expository texts. In fact, the use of these social studies texts in later elementary grades is becoming key to teaching critical literacy skills. This is due to the fact that there is often insufficient time given for students to develop these literacy skills in the language arts classroom. However, texts are necessary for all subjects. So, by using strategies like KWL and other similar thinking strategies, students not only gain knowledge in the subject matter, but also reading comprehension skills as well (Reidel & Draper, 2011). This transcends into a larger reality when students graduate high-school, without the needed literacy skills. In fact, research has shown that many students coming out of high school and attending college lack the reading comprehension skills necessary to be successful in higher education. Regardless of a student's major, reading comprehension skills are necessary for success in all higher education subjects (Anderson & Young, 2011).

In truth, nonfiction texts in other subjects, such as science, are often considered boring and difficult to understand. Lack of reading comprehension makes success in these fields even more difficult to obtain. Because of this, new techniques are being designed to help reading comprehension in these subjects. For instance, one study conducted on middle-school students used graphic organizers to help with textbook reading comprehension. The idea behind the study was that graphic organizers require students to write the information. Writing activates sensory memory and eventually ends up stored in the long-term memory. Additionally, it is believed that graphic organizers help students see the information visibly more structured. The study concluded that graphic organizers did indeed help with reading comprehension of a science

textbook (Ropič & Aberšek, 2012). Again, this helps highlight the needed skills for successful reading comprehension, such as engaging the text and structuring thoughts, which relates back to metacognition and interest in the text, which are predictors of success in reading comprehension.

Mathematics and Conceptual Math

Another key element to academic success is mathematics. Like literacy, NCLB also focuses on getting all U.S. students proficient in math (NCLB, 2002). There are many reasons that NCLB focused on getting students proficient in math. The primary reason was the concern that many students were not prepared for math at the college level upon high-school graduation. Recent research has continued to show that students lack the skills in math needed on college entrance exams, leading to remedial math courses. This means that skill deficits that should have been resolved while students in high-school were not. Students then have to spend time focusing on gaining the needed math skills before they can focus on completing their degree. There is additionally concern about the number of college students who do not graduate because they are unable to complete a college algebra or college statistics course (Jacobson, 2006). Of course, these results along with NCLB (2002) have put pressure on elementary teachers to better prepare students for both secondary and post-secondary education. Currently, in the U.S., curriculums are starting to focus more on teaching concepts instead of only teaching basic operations.

Conceptual mathematics looks at why and how a person should solve problem to arrive at a solution. Conceptual math is nothing new. In fact it is the oldest form of math, since it focuses on possible ways to solve real world problems. As previously mentioned, many curriculums are now more focused on teaching concepts rather than simply teaching operations. In fact, most states are now moving over to the common core state standards. Common core standards in

math are more focused on concepts rather than algorithms and equations. Common core standards allow teachers to spend more time on a concept than many other state standards did before. So instead of every year becoming a review of the previous year with an additional step or two being added, teachers are encouraged to spend time building concepts that can continuously be used throughout life. Students are also encouraged to defend their answer, and focus on real world examples. This should help students reach higher standards and comprehend the concepts more completely (Dessoff, 2012; Nisbet, 2012).

Conceptual math could also be call real world math. This is because concepts are not simply taught as a simple operation, but rather, through the lens of real world problems. The goal is to figure out possible ways to find a solution. These real world problems often take the form of word problems. In these word problems, students are looking for variables to make a calculation with. For instance, instead of simply subtracting or simply adding two numbers, students are figuring out a real world problem, such as who has more or less in a story. Units are often used, and the student must be able to correctly transfer the units, such as dollars or inches, to their answer. While there are many upsides to teaching concepts, some elementary students have difficulty comprehending word problems that are used in conceptual math. Simply put, children have trouble understanding and comprehending the words in these problems and then using concepts to solve the problems (Monroe & Panchyshn, 2005).

Needed Skills in Conceptual Mathematics

Because of the nature of conceptual mathematics, there are multiple factors that would build skills. Primarily, a student must be able to perform mathematic operations in order to be successful in conceptual math. Research has shown that teaching operations in Pre-K and early

elementary grades, and continually fostering interest in math is key to getting children interested and focused on being successful in math later on. In fact, research has shown that interest in mathematics in the Pre-K grades is a successful predictor for success in mathematics later on (Fisher, Doctoroff, Dobbs-Oates, & Arnold, 2012).

Another skill to build is number sense. Teachers do this by teaching very basic concepts until proficiency is achieved. Then they build on these concepts slowly, using prior knowledge until proficiency is once again achieved. This pattern continues until children at the early elementary and Pre-K ages have a good concept of number sense. Research has shown that basic principles of number sense in early elementary and Pre-K grades are the strongest predictor of success in mathematics (Witzel, Ferguson, & Mink, 2012). However, number sense and basic operations do not necessarily equal success in conceptual math. Number sense and basic operations are the groundwork needed for success, but conceptual math requires higher order thinking. This is one reason that many curriculums have moved or are moving to focus on concepts, since many previous math curriculums only focused on operations and number sense.

Another important aspect of conceptual math is breaking down the problem. As previously mentioned, many of these problems come in the form of word problems. So, students have to read the problem and understand what is being asked, which is a metacognitive process. They must find the numbers in the word problem that are valid and helpful in solving the problem. They need to be able to decipher whether the problem is asking them to add, subtract, multiply, divide, or some combination of the four. Then, they must turn the words into an equation they can solve. Research has found that elementary students have trouble understanding what the question is asking, if they have difficulty understanding the words that make up the problem. There are some suggested ways to take care of this. One way is to make word

problems easier to understand by relating the word problem to the lives of the students. The main concept here being that children do better when they can work with what they know, building off of prior knowledge (Monroe & Panchyshn, 2005).

Reading and Mathematics

There has been some question to the relationship between math and reading ability prior to this study. While other studies do not always look at the exact same variables as this study, there is some research that can provide evidence of the need for this study. For instance, research has shown that reading comprehension when paired with math computation skills was a predictor for applied mathematics performance of fourth and fifth grade students (Rutherford-Becker & Vanderwood, 2009). Another longitudinal study looked at reading ability and its impact on math scores of tenth grade students. The study found that the higher the reading ability of the student, the more likely the student was to have high math scores (Larwin, 2010).

One known variable to affect achievement is language proficiency. This is one reason that NCLB (2002) focuses heavily on making sure that all students are proficient regardless of social class or ethnicity. One of the main concerns is that English language learners (ELL) tend to perform more poorly than native English speaking students. One of the main factors that has been found to predict success in math word problems by ELL students is their ability to comprehend what they have read. The more complex the language and structure of a problem in comparison to language proficiency, the more difficult the problem will be (Martiniello, 2008). Another similar study performed in Ireland found similar results. Students who could speak English, but with a lower proficiency, scored significantly lower on a word problem based math test than students who were proficient in English (Ní Ríordáin, & O'Donoghue, 2009).

There is also a study that looked at reading comprehension of math texts. Essentially, math textbooks are considered to be materials that are difficult to comprehend. What the research concluded was that prior knowledge of the concepts increased reading comprehension of math texts (Österholm, 2006). This is similar to the effect that previously mentioned reading comprehension strategies, KWL, DRTA, text-to-text, text-to-self, and text-to-world, build on. This makes sense, since it is known that previous knowledge and experiences help with reading comprehension. Also, the same research found that texts that do not use symbols were easier to comprehend than materials with symbols, which could mean that symbols distract students from the major concepts (Österholm, 2006). Of course, this could be an important factor in creating word problems.

Another similar connection is that the reading of informational texts can assist with teaching math concepts. The idea is that the informational texts make that much needed real world connection with math. The student can now visualize a real object instead of simply seeing numbers in an equation. With these real world examples, teachers can build several concepts when compared to the limitations of a simple equation (Cummins & Stallmeyer-Gerard, 2011). Other research has shown that building vocabulary with fictional texts also helps in mathematics. The concept here is that fictional texts that require mathematical knowledge to understand the plot can be used to create interest and teach math skills. The same research also found that the use of texts like department store sales flyers, coupons, the sports section of the newspaper, and other similar real life texts are also helpful in teaching math concepts (Ming, 2012). All of these studies show the importance of making connections that help students identify situations they can think through using the metacognitive processes to arrive at solutions.

Math and reading have other connections that could implicate some connection between reading ability and ability in mathematics. For instance, research has shown that sections of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV), could predict both reading and math scores in gifted children (Rowe, Miller, Ebenstein, & Thompson, 2012). Another study found that scores on different sections of the Woodcock-Johnson could predict reading and math success in early elementary education. Also, the scores could predict whether a child would be retained or not (Moser, West, and Hughes, 2012).

Conclusion

Reading has been a predictor for math and both have worked together as reliable predictors for student scores and success as well. Additionally, reading comprehension and conceptual math also have some commonality. First, both reading comprehension and conceptual mathematics are skills of recognition. Students will have difficulty understanding the material or problem if they cannot recognize, understand, and calculate what is being said or asked. Also, both skills are built on prior learning and real world examples. Both skills require students to have the ability to not only read the data, but also correctly interpret the data based on the world they live in and the experiences they have had. In fact, prior experiences and knowledge will help the likelihood of success in both areas. Another similarity is that much of the needed skills, like breaking down the information, giving it structure, and using metacognitive processes, are key to both reading comprehension and conceptual mathematics. And finally, due to needed skills in reading comprehension and success in other subjects, it is possible that reading comprehension will be a factor in conceptual mathematics.

Methodology and Procedures

The purpose of this study was to determine the relationship between reading comprehension and conceptual mathematics of third grade students at a selected elementary school. The population for this study comprised of all students at an elementary school serving Pre-K through fifth-grade in northeast Tennessee. The selected school had a total of 423 students. There were 187(44.2%) female students and 236(55.8%) male students. The student body demographics were as follows; 5(1.2%) of the students were African American, 1(0.2%) of the students were Asian/Pacific Islander, 20(4.7%) students were Hispanic, and 396(93.6%) of the students were white. Additionally, of 423 students, 321(80.7%) were economically disadvantaged, making this a Title I school. Also, the school was a full inclusion school.

The sample for this study consisted of 27 third grade students. Of the 27 students, 25 were white and two were Hispanic. Four of the students were receiving accommodations for special education. Additionally, 15 of the students were female and 12 of the students were male.

Data Collection Instrument

Data for this study were collected in two parts. First, the students reading skills were determined by using the Star Reading Test. The STAR Reading test correlates highly with the national standardized tests and research based data driven decision-making. This study looked at 5 skills in the Comprehension Strategies and Construction Meaning domain of the STAR Reading Test. The five skills scored were; draw conclusions, identify and understand main ideas, identify details, identify and understand sequence, and understand vocabulary in context. The skill scores on the STAR Reading Test range from 0 to 100, with 0 representing a severe lack of skill in that area for grade level, and 100 representing a high-level of that skill for grade level.

The second part of the data collection comprised of teacher made test that was used to assess conceptual math skills. The assessment was based off the math skills that bad been taught in that current school year. The skills were then put into word problems, using real life examples and concepts, on a third-grade reading level. The assessment was then reviewed and deemed appropriate for third-grade students by the third-grade language arts teachers, the third-grade math teacher, and the school principal. The assessment consisted of ten questions that gradually increased in difficulty. Each question was assessed in two parts. Part one: was a valid method used to answer the question, showing the student understood what the question was asking. Part two: was the problem answered correctly, including units, i.e. inches, dollars, ounces, etc. Each part was worth 1 point, meaning the scores could have ranged from 0-20 points.

Procedures

Before this study was conducted, permission was sought from the principal of the selected elementary school and Milligan College IRB. When all permissions were granted the sample was identified. A letter of consent was sent to the parents of the students who could participate in the study. They were informed that participation was voluntary and that one could opt out of the study at any point without penalty. The study started immediately after all consent forms were received from the parents.

First, the conceptual math test was administered to the students and the tests were scored. Additionally, any required accommodations, according to students IEPs, were given. This means that four of the students had the test read to them. The total number of points scored, 0-20, became the students' conceptual math score. Next, scores in the areas of draw conclusions, identify and understand main ideas, identify details, identify and understand sequence, and understand vocabulary in context from the students' most recent STAR Reading test score were

aggregated. This aggregated score was referred to as the reading comprehension score. The conceptual math scores were measured against the five skill scores in reading comprehension from the students' most recent STAR Reading Test for data analysis.

Results

Two research questions were used to guide the analysis of data. Each research question was followed by a research hypothesis and a null hypothesis.

Research question #1: Is there a relationship between reading comprehension skills and conceptual mathematics skills?

Research question #2: What is the impact of the five skills assessed by the STAR Reading test on conceptual math scores?

Research question 1 was analyzed using Pearson Product Moment Correlation. The results yielded a significant correlation between reading comprehension and conceptual math ($r=.84$; $r^2 = .71$, $p = .001$). The results are displayed in Table 1.

Table 1

Correlation Between Reading Comprehension and Conceptual Mathematics

Variables	M	SD	r	r^2	Sig
Reading Comprehension	67.22	30.94	.84	.71	.001
Conceptual Mathematics	11.04	5.84			

Research question 2 was analyzed using Multiple Regression procedure. The results indicated a significant correlation between the five combined comprehension skills and conceptual math ($R=.88$, $R^2=.77$, $p=.001$). This means that 77% of the variance in conceptual

math could be explained by the combined five comprehension skills assessed by the STAR Test. However, none of these skills was a significant predictor of conceptual math when examined in isolation. This implies that all of the five comprehension skills are essential in understanding conceptual math.

Discussion

In regard to Research Question #1: Is there a relationship between reading comprehension skills and conceptual mathematics skills? A Pearson Product Moment Correlation showed that there was a significant relationship between reading comprehension skills and conceptual math skills ($r = .84$; $P = .001$). Therefore the null hypothesis was rejected. Additionally, the findings showed that the coefficient of determination was high ($r^2 = .71$) meaning that 71% of the variance in conceptual math scores can be explained by reading comprehension. This suggests that reading comprehension plays a major role in students' performance in conceptual math. Students who have strong reading comprehension skills have developed the ability to make connections within the text such as identifying main ideas, identifying details that support main ideas, defining unknown words using context clues, making predictions, and drawing conclusions from the information provided in texts. These metacognitive processing skills are similar to those used in conceptual mathematics.

In regard to Research Question #2: What is the impact of the five skills assessed by the STAR Reading test on conceptual math scores? A multiple regression was conducted and revealed a significant relationship ($R = .84$; $P = .001$) and a high coefficient of determination ($R^2 = .77$). This means that the five predictor variables (draw conclusions, identify and understand main idea, identify details, identify sequence, understand vocabulary in context) can account for

77% of the variance in conceptual math scores. However, none of the variables were significant predictors in isolation. This suggests that each of the predictor variables is reliant on the others to predict conceptual math scores.

Overall, this study showed that reading comprehension and conceptual math have a strong relationship. Additionally, reading comprehension scores can predict conceptual math scores in third grade students. This is consistent with the study conducted by Rutherford, Becker, & Vanderwood (2009) that showed reading comprehension scores can be a predictor for applied mathematics scores in fourth and fifth grade students. This is also consistent with the results of the study conducted by Larwin (2010) that showed reading ability of tenth grade students could predict math scores. I believe that this is in large part due to the nature of the meta-cognitive processing skills required in both reading comprehension and conceptual math.

Conclusions

The purpose of this study was to determine the relationship between reading comprehension skills and conceptual math skills. Overall, both a Pearson Product Moment Coefficient test and a Multiple Regression test indicated that reading comprehension skills have a significant relationship with conceptual math skills. However, the multiple regression showed that between the five skills of the STAR Reading Test that were assessed for reading comprehension, no one individual skill was a significantly greater predictor than the other.

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